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EXHAUST EMISSION ANALYSIS OF THE WILLIAMS RESEARCH GAS TURBINE VOLKSWAGEN

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16. Abstracts: The Williams Gas Turbine, 131-Q, regenerative turbine automotive engine was mounted in a 1965 Volkswagen squareback test bed. The engine utilizes a two stage turbine to develop 70 horsepower. It incorporates the standard VW automatic transmission coupled to the engine through a gear reduction system. Non-leaded gasoline was used as fuel for these tests. Tests were conducted using the standard 1972 Federal Test Procedure using the LA4-S4 driving cycle with constant volume sampling. Exhaust samples were analyzed for: nitrogen oxides, carbon monoxide, hydrocarbons. Results are discussed and tabulated. The following conclusions were drawn: by averaging two sets of data, it was determined that the test vehicle did not meet the 1975 standards. Because a new combustor design had been incorporated in the engine, it was unadvisable to perform a larger number of tests. Until such tests can be performed, a positive determination of emission levels cannot be made. The driveability of this turbine car did not compare to a conventional internal combustion engine vehicle.

17. Key Words and Document Analysis. 17a. Descriptors

Air pollution
Exhaust emissions
Gas turbines
Tests
Standards
Nitrogen oxides
Carbon monoxide
Hydrocarbons

17b. Identifiers/Open-Ended Terms

Williams gas turbine
Volkswagen
Federal Test Procedure (1972)
Constant Volume Sampling Technique (CVS)
LA4-S4 driving schedule

17c. COSATI Field/Group 13B

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Emission Results

The normal practice of subtracting the concentration of the background hydrocarbons in the dilution air from the hydrocarbon concentration measured in the CVS bag could not be used in this study. When sampling from low emission vehicles the hydrocarbons in the dilution air can contribute a major portion of the total hydrocarbons and the straight subtraction correction is no longer rigorous. Since the volume flow of the engine was known an alternate more correct calculation procedure could be used.

The concentration (C_t) of the diluted sample in the CVS bag can be expressed as follows:

$$C_t = C_e \frac{V_e}{V_t} + C_b \frac{V_t - V_e}{V_t} \qquad (1)$$

Where:

C_t = concentration of total sample in bag

C_e = concentration of integrated undiluted exhaust volume

C_b = concentration of background contaminant dilution air

V_t = volume of total sample (exhaust plus dilution air)

V_e = volume of exhaust

Equation (1) can be rearranged solving for concentration of exhaust (C_e):

$$C_e = (C_t - C_b \frac{V_t - V_e}{V_t}) \frac{V_t}{V_e} \qquad (2)$$

The weight of emission (gm/mi) of each pollutant is obtained from:

$$W = K\ C_e\ V_e^1$$

Where: K = constant relating weight of emission to volume of exhaust per mile

V_e^1 = volume of exhaust per mile

Four LA 4-S4 tests were run, there was one aborted test because of a leaking exhaust manifold. There is some question to the validity of test #1 due to suspected sample contamination.

In Table 1 comparisons are made of all three tests using the 1972 Federal test procedure. Hydrocarbons in tests #2 and #3 are consistent, but in test #1 the value is considerably higher possibly reflecting the hydrocarbon contamination mentioned above. Carbon monoxide data is inconsistent, and nitrogen oxides also show a slight inconsistency.

In keeping with report policy for tests such as these oxides of nitrogen will be reported as NO_2 and an overall value will be arrived at by averaging two sets of data.

Conclusions

By averaging two sets of data it was determined that the test vehicle did meet the 1975 standards; however, it should be noted that some slight inconsistencies do exist.

Because a new combustor design had been incorporated in the engine it was unadvisable at this time to perform a larger number of tests. Until such a series of tests can be performed to substantiate the data collected during this short test, a positive determination of emission levels cannot be made.

The driveability of this turbine car did not compare to a conventional internal combustion engine vehicle. Very little engine retardation was evident; acceleration was smooth but not rapid.

Table 1

1972 Federal Test Procedure

	Test #1* 12-1448	Test #2 12-1449E	Test #3 12-1455
HC gpm	.89	.36	.32
CO gpm	1.78	5.4	3.6
CO_2 gpm	1086.5	1094.5	988.4
NO gpm	1.44	1.55	1.27
NO_2 gpm	2.21	2.30	1.95

Average of tests #2 and #3:

HG gpm	CO gpm	NO_2 gpm	NO_x**
.34	4.5	2.12	1.81

NO_x corrected for Humidity:

Test #1	Test #2	Test #3
1.92	1.97	1.65

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gpm indicates calculated mass in grams per mile.

* not used in calculations because of possible effect from the sample contamination on emissions.

** NO_x corrected for humidity.